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AN ELECTRIC APPARATUS USED IN THE

Diagnosis of Diseases of the Nervous System.

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Before presenting the battery to you, I take the liberty of making a few remarks regarding the requirements of a battery which is to be used in the diagnosis and treatment of diseases of the nervous system.

Whatever may be thought as to the therapeutic value of electricity, there can be no doubt that it is an essential factor in the diagnosis and prognosis of many diseases of the nervous system. By it we recognize and determine changes in the excitability of the nerves and muscles, and from their reactions to it we are able to say, this nerve is degenerated, that muscle is not.

In many cases of paralysis due to injury of nerves we are able, being guided by the electrical reactions, to give a fairly definite prognosis as to the time when the patient may look for a return of power in the affected muscles.

Two forms of electricity are used in diagnosis, the induced or interrupted current, commonly called the faradic; and the galvanic or constant current. Nerves and muscles under various conditions respond differently to these two currents, and our apparatus must furnish both.

We not only have to determine that this or that nerve or muscle responds to the faradic or galvanic current, but we must also know just how strong a current of each is required to bring out the smallest visible contraction and how strong to cause a tetanic contraction, etc. Our apparatus must be so arranged that we can vary and estimate the strength of the currents used.

Nor is this all; for it has been shown that the strength of the electrical stimulus varies not only with the strength of the current, but also with its density; and as the density of the current under the exciting electrode depends upon the square surface of that electrode, we must have electrodes of known square surfaces. Finally, as the electrical excitability of nerves and muscles to the galvanic current differs according as the exciting electrode is positive or negative, and as the current is made or broken, we must be able to reverse the current, and to make and break it.

Any one who has made electrical examinations knows that under the very best conditions it is a tedious and tiresome undertaking, and will agree that the apparatus should be made as simple and convenient as possible.

An electrical apparatus which is to be used in the wards of a hospital must be so contrived that it can be brought to the bedside of any patient, and it must contain everything that is necessary for an accurate examination.

Two methods were considered in connection with this hospital. The first was to have a large battery composed of storage cells, situated at some central point, and connected with all the wards by wires, so arranged that a table bearing the necessary apparatus could be brought into the circuit at any desired place. This, although attractive, was found to be very expensive and not simple enough.

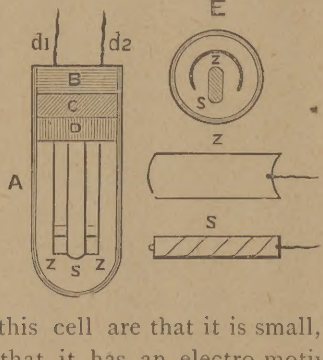
The other plan, and the one which has been adopted, was to construct an apparatus which could be easily moved from place to place, and which should contain all the necessary appliances as well as the battery itself.

There is nothing especially novel in this plan, as it differs only in detail from that which is adopted in most hospitals. *We were, however, peculiarly fortunate in having the assistance of Dr. G. A. Liebig, of the University, and Mr. Charles Willms, of this city.* These gentlemen spared no pains in putting our ideas into a thoroughly scientific and practical shape, and I take pleasure in presenting in evidence thereof the apparatus which is now in daily use in the wards.

In the construction of such an apparatus, the most important practical point is the kind of galvanic cell used to furnish the electrical current.

To furnish a current of sufficient strength the battery must be composed of a large number of cells. In this apparatus there are 100, and as the battery is portable, the size, weight and construction of the cells is of the first importance. If they are large and heavy the battery becomes clumsy and practically stationary. Those cells which contain fluid are dirty and troublesome. So other things being equal, the smaller, lighter and drier a cell is the better.

THE CELL WHICH MEETS ALL THESE REQUIREMENTS FAR BETTER THAN ANY OTHER KNOWN TO ME IS THE DRY CHLORIDE OF SILVER CELL, AS NOW MANUFACTURED BY **THE CHLORIDE OF SILVER DRY CELL BATTERY COMPANY.** The cell is composed of a rod of fused chloride of silver (*S*) and a plate of zinc (*Z*) immersed in a paste saturated with sulphate of zinc. The cell is very tightly sealed, and when complete measures 2¾ inches high and ¾ inches in diameter.



The advantages of this cell are that it is small, light, perfectly clean, always ready for use, and that it has an electro-motive force (one volt) which *remains constant during its entire life.*

It may not be out of place here to recall the fundamental law which determines the strength of a current from such a cell. It is called Ohm's law and is as follows: The current is equal to the electro-motive force of the cell divided by the resistance of the circuit, and is written $C = \frac{E}{R+r}$, where C is the current, E the electro-motive force, R the external resistance, and r the resistance of the cell itself.

Now the electro-motive force depends solely upon the nature of the metals used and on their temperature, and is affected in no ways by their size.

The resistance which a conductor offers to the flow of an electric current depends upon its nature, and is directly proportionate to its length and inversely to its square surface; or, applied to the internal resistance of a cell, this is greater the smaller the plates and the greater the distance which separates them.

Here it is evident that the size of the cell may make a great difference in the strength of the current, for if in the formula $C = \frac{E}{R+r}$ the external resistance R is very small when compared to the internal resistance r, we can increase the current very materially by decreasing the internal resistance. And indeed if R is to be disregarded, this is the only way we can increase the current strength; for by increasing the number of cells we simply multiply the numerator and the denominator of the fraction by the same factor.

This is the condition that has to be met in batterries designed for electrocautery work, where the external resistance is small, and so in these batteries we have a few very large cells.

But in the diagnosis and treatment of diseases of the nervous system, where the current is passed through the body, and its resistance, which is very great indeed, makes the only essential part of the total resistance, the conditions are reversed, and R is so large in comparrison to r that the resistance of the cell itself may be disregarded to a very great extent, and here we depend not upon the size of the cells but upon their number. From this it is evident that the little chloride of silver cells answer our purpose perfectly, provided we have a sufficient number. By the passage of the current through the cell, the chloride of silver is reduced to metallic silver, and this change is directly proportional to the current; that is, if a very strong current is passed through the cell, the reduction goes on very rapidly and the cell is worked out in a short time. For this reason, in using these cells care must be taken not to short-circuit the battery, that is, close the current with little or no external resistance; for if through carelessness this were done, the battery wonld be ruined in a night. This is the one disadvantage these cells have.

The life of the battery depends entirely upon the current used, and the electro-motive force is said to remain constant until all the chloride of silver is reduced.

There are one hundred cells in the constant current of this battery, arranged so that ten cells can be brought into the circuit at one time.

As has been said, it is of very great importance to know just how much current we are using, so we have introduced into the current a galvanometer, which is calibrated to read in milliamperes, or, in other words, it is an absolute galvanometer.

We can with any given number of cells change the strength of the current by introducing more or less resistance. This is done in the ward battery by passing the current through a water rheostat, in which we can vary the distance through which the current has to pass in the water.

In regard to the induction apparatus I shall only say a few words, as the principle which governs it is well known. It is composed of a primary and secondary coil. The primary coil is in the circuit of a battery, composed of several chloride of silver dry cells. Into this circuit is introduced an electro-magnetic interrupter which makes and breaks the current very rapidly. The secondary coil is so constructed that it can be freely moved over the primary coil. Every time the current is made or broken in the primary coil a current is induced in the secondary coil, and this induced current is the one which is used in diagnosis. The strength of the current in any induction apparatus depends upon the strength of the current passing through the primary coil, the rapidity with which that current is made and broken, and upon the distance of the primary from the secondary coil.

We endeavor to keep the first two factors constant and speak of the current as stronger or weaker depending on the distance of the coils.

The scale on this apparatus is relative, *i. e.*, the strongest current which can be obtained from it is taken as 100, and the other numbers on the scale represent relative current strengths.
